

"BBN Job #41540"
Howard Frank
Tape Number One
-- CARIBINER GROUP

(OFF MIKE)

QUESTION

HOWARD FRANK

Okay. For the record, my name is Howard Frank.
I'm ... uh ... at ARFA(?), which is what I'm
doing now. Where I was in nineteen sixty-nine,
was at, uh, Network Analysis Corporation where
I was president of the company and founder.
And, uh, what I was doing then was trying to
survive ... okay ... in business.

QUESTION

HOWARD FRANK

Presently, I'm trying to survive by not getting too
much overworked(?), beyond what I am doing
right now.

QUESTION

HOWARD FRANK

Okay. I am special assistant to the director of ARPA, for information infrastructure technology. And, uh, in addition to that, I have another full time job, which is director of an office that is responsible for technology transition from ARFA into the Defense Information Systems Agency.

QUESTION

HOWARD FRANK

That is (Overlap)

QUESTION

HOWARD FRANK

Right. You know, the problem of talking, uh, about this is that you have to take a very deep breath ...

QUESTION

HOWARD FRANK

... to get the full title out. And quite often you have to use both sides of the cards.

QUESTION

HOWARD FRANK

Yeah.

QUESTION

HOWARD FRANK

The first time I heard of ARFINET(?)? Well, for some reason or another, uh, I met Larry Roberts. And I met him in nineteen sixty-eight. At the time, I was working in government also. I had come from a year ... from ... on leave from Berkeley. And, uh, somehow I met Larry. And he asked me to dinner. And, uh, our wives and some other people were at dinner. And we was talking about some rather ... farfetched notion about computer communications. And I thought he was ... was kind of odd ball(?). And his ... I thought he was looking for money. You know, which I didn't have. And so I was trying to defend myself. And I basically think I ignored him. Okay, certainly ... I ... I must have ignored because I didn't see him again for about

a year. So the second time I heard of ARFINET, somebody told me about it. It may have been Winn(?) Klein(?). Or (Inaudible) it might have been ... uh ... somebody else(?) said, "Go talk to this guy, Larry Roberts. He's building a network that, uh, you guys could help in(?)." And so I

went. And, uh, Larry showed me a little picture.

And the picture was four nodes(?) on the west coast. And some communication lines that had been drawn(?) to additional nodes that were being, uh, put into the mid-west and also put into, uh, the east coast. And he said, "We've(?) got these four things operating. Uh ... I've sketched these out with basically a calculator and a ... and a ruler and a pencil. But I have no idea whether or not these are the right ones.

Whether they're the wrong ones. Whether I should be, uh, putting more lines in. Whether

^{visible} it's flyable(?) enough. Whether it's got enough

^{through} ~~blue~~

put(?). Whether it costs too much. And

could you guys help?" And at the time, I had just started my company. A few months before that. Network Analysis Corporation. Which is in the function of business ... of optimizing that stuff. Okay? You could think of more boring things, but, uh, I don't have enough time to actually think about it. Uh ... and we said, "Yes, indeed." They(?) wrote an unsolicited proposal for thirty-nine thousand dollars. And said in four months what we will do is we'll come with a design and a new technology for how to design these networks. We did. And four months later I showed Larry a design which had thirty percent less costs(?). And forty percent more through(?) put(?). And Larry said, "Great. Here's my pencil. Okay. You guys are now it. Okay, and by the way, write me another proposal. I've got thirty thousand dollars more I that I need to spend before the end of the year." And, uh, we were in business. You know, in ... in designing

the ARFINET.

QUESTION

HOWARD FRANK

Yeah, I think they would.

QUESTION

HOWARD FRANK

Right.

QUESTION

HOWARD FRANK

You know, one of the questions you could ask of, uh, you know, why did Larry call on us? Uh ... we had just formed this company. Nobody had ever heard of us. Uh, on the other hand, we had formed the company because we had just had a very successful one year stay in the, uh, executive office of the President of the United States demonstrating that network technology could be applied to real world problems. And we had done something very strange. Actually, for ... it was bizarre if you think about our

backgrounds. We had applied some academic theoretical technologies and computer technology to the problem of designing off-shore natural gas pipeline networks(?). Now, frankly, at the time, I had never even seen a off-shore gas ... natural gas pipeline network. In fact, I still may have never seen one. I have seen films of them subsequent to that. Uh ... most of my guys, uh ... cooked with gas, and that's as close as they ever got to it. And, yet, we had been able to come with a mathematical and(?) computer discipline that could optimize those networks irrespective of the material that they were transporting. And so Larry made this, uh, in ... intuitive, inductive leap, that said if they can optimize a gas pipeline network, and they can optimize a different kind of network, then maybe what(?) they can do is they can do the same thing for a computer communications network. And, indeed, he was right. And, in

fact, our backgrounds were such that we were all electrical engineers and computer scientists anyway. So this was a natural thing for us to gravitate towards.

QUESTION

HOWARD FRANK

Hmm.

QUESTION

HOWARD FRANK

Mm-hm.

QUESTION

HOWARD FRANK

Oh, when ... when Larry said, uh, "Would you like to do that?", I immediately thought, uh, "Thirty-nine thousand dollars. That's terrific.

We can use the money." I ... uh, we can generally, uh ... my people at Network Analysis Corporation were as smart as they came in the world. They were very hard working. They were terrific guys. And, uh, they could ... if ...

Best
for
Network
is a
network

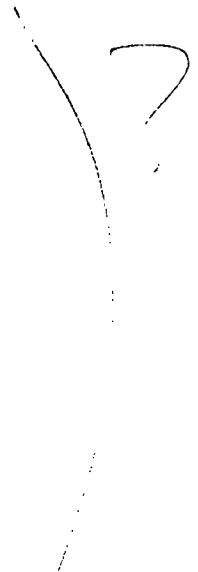
of fun to be in the business. See, we were doing lots of things that were new. And a nice thing about walking into a new field, is that an expression called, uh, picking the low ... lying grapes ... the low lying apples. (It's very easy to reach up and pull down an apple that's never been picked yet from a tree. Now, on the other hand, if thirty-three people have been through that orchard already it's very hard to get the last apples. And what we were doing is we were explorers in a field, that nobody had ever worked in before.) (And so, therefore, it was easy to do good things. That's a ... the way to really be successful in life, is to find new fields sufficiently frequently that you always do easy things once you find them. So I think that was the ... the really interesting part about it. And, by the way, Network Analysis Corporation, my company ... uh, we had two qualification for, uh, for working there. You, uh, had to have a ... good computer

background. And you had to have a good pair of sneakers. Because we used our lunch times and after work to play, uh, football, baseball, ping pong. And a variety of other things. And we spent at least two hours a day playing sports. You know, throughout, maybe let's say a ten, fifteen hour week, uh, day. E.. we'll fix that up. We spent ... uh ... generally we did actually spend about two hours a day in sports in something like a twelve, fourteen day ... work day.

QUESTION

HOWARD FRANK

No, you know the ... the funny thing is that, uh, if you look at the individuals, you might think of these people as ... as introverted, uh ... specialists who think nothing but, uh, networks and physics and electrons or whatever. Uh, on the other hand, it's not really the case. Uh, they're ... they're deep ... uh ... deep people



who worried(?), uh ... had ... had lots of different interests. For instance, I have a ... a huge collection of Science Fiction books. And ... and, uh ... art ... Len Kleinrock is, uh ... you know, a very, very wide(?) person. These people are ... sort of the ... the leaders of an intellectual and entertainment communities, simultaneously. Because they're fun to be with. And they don't just talk networks. Okay? In fact, it used to drive me crazy. You know, I would go off on a trip with Lenny and with Larry, you know, uh ... and these guys liked to work puzzles. And I'd be sitting in the back of the car or the front of the car, and they'd be saying, "What happens if a man on a boat drops his hat into the stream and the water is running down at the ... this rate, and the bird comes and he lands on the hat. But the bird is flying and accelerates and so(?) ..." and I ... I only solve problems for money. And these guys that were driving in the middle of the night,

you know, from somewhere to somewhere else.
And they're working on these little puzzles all the
time.

QUESTION

HOWARD FRANK

Yeah.

QUESTION

HOWARD FRANK

Right.

QUESTION

HOWARD FRANK

Actually I ... I met ... I met ...

QUESTION

HOWARD FRANK

Right.

QUESTION

HOWARD FRANK

Right.

QUESTION

HOWARD FRANK

Okay. I met Len(?) Kleinrock, uh, maybe five years before I actually got involved with ARFINET. Uh ... maybe even more than that. Actually I met him on paper earlier than I met him in the ... in the real world. Uh, I was in the book store at ... uh ... Northwestern, where I was doing my Ph.D. And I picked up a book called Communication Networks: ~~The~~ ^{Stochastic} ~~Case~~ (?) Message Flowing ~~the way~~. And for a very short time I thought that Len had done my Ph.D. thesis. Which would have destroyed me. Uh, it turned out he was working on a different aspect of a similar problem. And so, therefore, I was home free. When I went out to Berkeley, I called him up. And, uh, we met. In fact, the first time we met, he, uh, was a guest lecturer in a course of mine. And was on vacation and nearly got killed coming down a mountain when his brakes went out. And so that(?) when he came to actually lecture in the course, he was using four

... two by two ... or four by four glass slides.
And there were cracks through all of them,
where his car had run off the road. So that was
the first time. And we became, uh, good friends
and ... in that period of time. So that we knew
each other rather well by the time we got to
nineteen, uh, sixty-nine and seventy.

QUESTION

HOWARD FRANK

Yea ... in the ... in the context of, uh ... of
ARFINET, what was going on was that people
were working individually. Okay. Quite often
using their own, uh, sort of view of the earth.
Okay. You know, Len has ... has a modeling
view. For instance. Trying to ... to measure
things and extrapolate using theory. Uh ... Bob
Kahn view of the earth was we're going to ...
we're going to build it and see if it works. Okay?
And then see how it works. And I was off doing
contological(?) design ... network design, that is.

*

And ... and trying to build models which then could be extrapolated to the, uh, large scale systems that couldn't be built yet. And what we discovered was that we all came up with the same conclusions. And so while we were ... every once in a while we would meet. We'd meet at a principal investigators' meeting. We'd meet at a ... some meeting in Washington or some, uh, technical meeting somewhere. And we began interchanging ... exchanging notes and ideas. And we discovered we were really working on ... on ... different aspects of the same problem. And coming up with the same conclusion. Which is ... interesting because truth is truth. And shows you can find different ways of ... of getting at the same kind of truth. The ... the modelers ... were very different than the ... empiricist(?). Uh ... uh, even today, if you look at an empiricist, it's a ... there's no point in theoretical modeling. You can't model the real

world. And, in fact, there's some proof that the (Inaudible) ... because, uh, the real world ... who would want to model the real world? It's too hard? Right? You could only model what's in your head. And that certainly isn't the real world. On the other hand, the, uh ... the modelers would say empiricists(?) can't test everything. They can only build small things. They can't ... you can't build the thing that's going to exist in the year two thousand and ten. So therefore you have to have models to extrapolate. And, you know, I can ... I hear this debate as well as I heard it in nineteen sixty-nine and nineteen seventy, nineteen seventy-one. And the reality is they're both right. And they're both wrong. Because you have to do both. And, in fact, I was at a meeting just two days ago where, uh ... I was arguing with modelers who wanted to build an ... a gigantic model of something. And I was arguing with the

empiricists who wanted to empiricists who wanted to build a gigantic, uh, physical thing, and I said, "You have go to combine them. You've got to combine models and empiricism together." And, indeed, that's the way most successful have been built. That's the way ARFINET turned out to ... to roll(?) out(?).

QUESTION

HOWARD FRANK

That ...

QUESTION

HOWARD FRANK

There really was no one crazy person. Okay? Who had a view of the world that was so different that it either, uh, energized, uh, a bunch of other people or proved a bunch of other people wrong. Okay? There really were independent views. Uh, these things tend to be ego based as much as anything else. Uh, in particular, uh, you do what you want to do.

Okay? The ... that was, I think the real dynamic of ARFA and ARFINET, was they got a bunch of bright people, okay, with good ideas. And they liberated them to follow up on those ideas. And there wasn't a very heavy strong interaction. There was a ... a loosely coupled(?) interaction. Where they would get together every few months. Or every six months. And they would exchange ideas. And they'd get incorporated. And we'd write papers and we'd do all kinds of stuff like that. But then we'd go back and say, "Now, okay. Now we're going to do it the way we think it should be done." And the way we'd think it should be done would be different from one place to another place. Because not everybody had the same responsibility. The ... the room for diversity was such that we could really ...

QUESTION

HOWARD FRANK

Is (Inaudible)

(OFF MIKE)

(CUT)

QUESTION

HOWARD FRANK

You know, the ... it has been proposed that a metaphor might be Larry Roberts is manager and ARFINET is a team. Or the ARFINET contractor is a team. Except I don't think you can ... win a game with ... with that team. The way we were organized. Because, uh ... in a team ... for instance, a football team, you're(?) going(?) to have somebody who calls signals. And you're going to have somebody else who ... uh, is going to throw^w~~ugh~~ a ball. And he tells everybody where to go and ... exactly who (sic) to block and etcetera, etcetera. And it's got to be very precise and ... and very well structured and timed down to the split second. Whereas, uh, what we really had going was a ... a number of,

uh, liberated intelligent people who were sort of playing to a long range strategy(?) and(?) game plan. Like Larry Roberts saying, "We need a network design capability." But not saying, "You've(?) got(?) to produce it." But(?) Al(?) and Harry(?) said(?) "How are you going to do it? And here's the technology to get a run(?) on(?). And here's what you're going to ... uh, you know, here are the lines that you're going to, uh, come up with. And, uh, here are the people that going to actually go into that." So there was nobody on the day to day(?) calling signals. Uh, so that it was more of a ... an affiliation. If you can think about a project as an affiliation, as an alliance, as opposed to a team, uh ... you get ... in this kind of science ... which was not meant to ... last two or three or four years, and then go away. You know, and the project is done. Uh, this was the ... the best kind of team in that way. But it would never win a football game.

Now, also I think, you know, that(?) one of the issues of these, you know ... everybody in the ... so to speak team, was so different that, uh ... you would discover if you put them together in an actual team ... they would probably rip each other's throats out. Okay? Because everybody ... you know, knew the right way to do it. Okay. Fortunately, they weren't ... no one else was doing my job. And I wasn't doing modeling.

And, uh ... and certainly I wasn't trying to build an imp(?). Because if I tried to do that, uh, Frank Hart was armed with, uh, a minimum of a large axe and ... and a machete and a machine gun. Uh, in particular, uh, one time, uh, we came up with a new routing(?) algorithm. And, uh, after, uh, three or four or five months of, uh, of belligerent but friendly, uh, negotiation, Frank admitted how ... that might be a good idea some day. On the other hand, the routing in the ARFINET worked. So maybe we didn't need that

idea that day.

QUESTION

HOWARD FRANK

I think maybe entrepreneurial control freaks are, uh ... a good analogy. But ... maybe the word control was a little bit too strong. I ... certainly entrepreneurial and freaks are ... are good ones.

Uh ... certainly impassioned and sometimes

obsessive are good ones also. And if, for

instance, you want (Overlap)

QUESTION

HOWARD FRANK

Okay.

QUESTION

HOWARD FRANK

Right.

QUESTION

HOWARD FRANK

If ... if I were going to characterize the ARFINET team, uh, what I would really do is I would

characterize everybody as individualists. You know, very wide ranging. Very rugged. Very ... you know, very survival (sic) individualists. You know, every one of them would ... was ... brought some very unique interests ... uh, very unique doesn't sound right, because it's ... every ... every one of them with unique interests. Uh ... in particular, ask(?) Lenny Kleinrock about, uh ... machetes and, uh, silver coins. Or ask Lenny and Larry about, uh, radios and casts and ... and how ... how they fit into Las Vegas.

QUESTION

HOWARD FRANK

Right.

QUESTION

HOWARD FRANK

You know in terms of trying to understand what kind of people these are. Uh ... ask Lenny about, uh ... machetes and, uh, silver coins. And ... and ask Larry or ... or Lenny about, uh ... poker,

good
radio to
Lenny Kleinrock

Las Vegas, radios, and arm casts.

QUESTION

HOWARD FRANK

Just(?) to answer(?) the question, this is, uh(?) the audience. Uh, you should realize that I've been asked a question which is guaranteed if I give you the right answer is going to put you to sleep. Okay? And the question is tell ... talk about topology, ARFINET, characterizing all this stuff. Modeling networks etcetera, etcetera, etcetera. And tell it in way that, uh ... that anybody could understand. Right? The answer is ... that ... think about a highway system. Okay? Most of the time, it doesn't work. Okay? In particular, when people want to use it it doesn't work. What we were asked to do is figure out how to lay down the infrastructure of the ARFINET, which in a way is a highway system for electrons(?), in such a way that the lines go in the right places. That when too much

*Good
opening for
Frank*

traffic gets on the net(?), it doesn't keep you from eating dinner at home. Okay? And that, uh ... you don't run out of gas. Okay, what you'd like to do is be able to get from here to there in a reasonable amount of time, at a reasonable amount of cost. Now, what we had to do to do that, is go through a number of elaborate technological calculations. One ... one of the things we recognized early was that the theory was inadequate to be able to, uh ... to solve the problem. So we ... we came up with the idea of using the power of the computer doing(?) multiple comparisons and calculations as a replacement for a theory which didn't exist. And so, for instance, we came up with the idea of, uh ... for instance, let's think about the game of chess. Uh ... if you tried to analyze all the combinations in chess, you would quickly run out of computer time or ... or brains ... or ... uh, or patience. On the other hand, I can give you a

number of relatively good rules for how to play a good game of chess. Like for instance in the opening don't move the same piece twice.

Okay? Another good one is don't start with pawn to rook four. All right. Don't look(?) at the edges of the board. Go for ... go for control and power first. In the center of the board. Okay?

What we were able to do with the ... world of network topology was build in a number of very sensible based(?) network rules combined with the ability of the computer which could look at lots and lots of things built around those rules, that could say ... these make sense as network choices. And they could look at enough of them so that when I put it all together, what we could do, was better than what a human being could do without the computer. And, therefore, what we decided to do is call(?) those optimal networks. And(?) definition was(?) optimal was as a good as I could do on the day I did it. I ... I

... as opposed to ... the best that anybody could do for the life time of the universe. And so in ...
... in it ... in non technical jargon, what we were able to do is come up with a technology using essentially computers to move lines and points around in a fine ... on ... computer logic, as opposed to in the physical world ... in enough ways and in enough combinations that we could pick out in(?) very inexpensive, well performing networks that were better than what human beings without the computer could do by themselves.

QUESTION

HOWARD FRANK

* Well, it ... it's been interesting. Because lots of times, uh, I've been asked the question, "Did ... did you guys have any idea about what the future of this stuff would be? You know ... did you realize how ... how ... powerful ... how ... how grow ... grand the ... the concept would

become. How ... how dominant in the real world it is." And usually the ... the, you know, the person asking the question is, uh ... surprised because he expects the answer, "No." Well, I would say the answer was really, "Yes." I think, you know, if you ... if you look at the number of the people that were involved ... fully half to two thirds of them believed(?) that this was a technology that would, indeed, conquer the world of communications. You know, I was a believer in that. I wrote about that in the ... in the early nineteen seventies. Bob was one. Larry certainly was one. Uh ... Len Kleinrock was one. Uh, you know, the ... I think most of the people that were involved in the original ARFA project ... even though, for instance, I came to it thinking this was maybe even Lawrence ... you know, Larry ... Lawrence Roberts' Boondoggle. Maybe. I heard the word. And I had no idea. It was initially ... looked like a

good way to get some good contracts. Uh ... once we started looking at the technology and seeing what it's impact could be and analyzing how it might roll out the services across the United States, we quickly became if not fanatics, we quickly became true believers at it. And, indeed, we were proven right. So I think we did have ... we did have that vision. You know, maybe ... uh, lots of other fields that ... you know, the ... the original pioneers never thought how their children might turn out. But in this particular case, I ... I would think if you would go around and ask that question, most of the guys are going to say, "Yes."

QUESTION

(OFF MIKE)

(CUT)

(OFF MIKE)

QUESTION

HOWARD FRANK

Okay.

QUESTION

(OFF MIKE)

HOWARD FRANK

These guys are not only amazing, they're really clever. To give you an idea of some of that, uh ... ask ... ask Larry Larb (sic) ... Roberts about Black Jack, Las Vegas, and computers.

QUESTION

HOWARD FRANK

My pal Lenny. Uh, Lenny and I have been friends now for thirty years, so I can probably say that he writes the worst poetry I've ever read. Uh, ask him to read something for you.

*Lead-in
to
Clunrock
Reading
Poetry*

QUESTION

HOWARD FRANK

Okay. Okay. Let ... let me give you an idea of ... of how this work (sic). Okay, first of all, Larry does call us in. And he says, "here's this picture". And he pulls out really a map. Okay?

And there are four nodes here and there are some heavy mines(?) connecting it. And then he says, "Well, and there are fifteen nodes here that I am planning on putting in. I'm not quite sure when they are going to go in. But then there is going to be another or so that are going to come in after that. I'm not quite sure when or in what order." And he says, uh, "Here are some figures and diagrams. And ... and here's the ... the lines that I(?) have(?) actually ordered. And we've(?) got(?) to tell the company ... the telephone company, whether or not I want to keep those lines within the next four months. I've got to give them answers." And he says, "The problem is I don't know whether those are the right lines to put in. Whether they cost too much. Whether they give the right performance. And I don't know, after I add the next bunch of nodes, whether they're still going to be the right ones. Well, for instance, am I going to have to pull

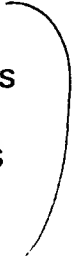
them out and put a bunch of additional lines in there?" And so, uh, he says to us, "Go talk to Len Kleinrock. Len has got these requirements. Right? He knows ... he's got a picture of what the traffic is going to be on this network. And he's got a picture of when the sequence of nodes might come in. But it's really not quite accurate. Okay? So try to figure out how you could lay down this network topology in such a way that it's cheap to begin with. Gives me the performance I need. And I don't have to rip it out each time I want to add new lines. Okay. And come up with that in four months. And, by the way, not just an answer, but a way of doing it from now on. So that we have a technique." And that's what we did. We came up with a computer program that could ... when you specified the locations ... would lay out the network for you in a very ... efficient way. But at the same time, it took, you know, hours of ...

of computer time at that point in time. And(?) would give you a network lay out(?). And then what you could do, is you could go and say "Now, what if these nodes went in in a different order?" And you could get another network lay out. And you could do that because the computer could give you enough answers, that you could do it enough times so that you could then say what makes sense independent of the exact order of where the nodes are going in, uh, Los Alamos first and ... uh ... Harvard second ... or MIT second and ... whatever. Uh, you could do it in such a way that you got a sensible initial design. And which it didn't have to be perturbed too much ... uh, just to add it on to. And so that's what we did.

QUESTION

HOWARD FRANK

I'm on, doctor. Okay. In twenty seconds or less what we did was we figure out how to add lines



initially so that they were cheap. And how to augment those lines by adding additional lines to them so that we could bring in new nodes as they came in. Even though at the beginning we didn't know what those nodes were going to be.

QUESTION

(OFF MIKE)

(END OF TAPE ONE)

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